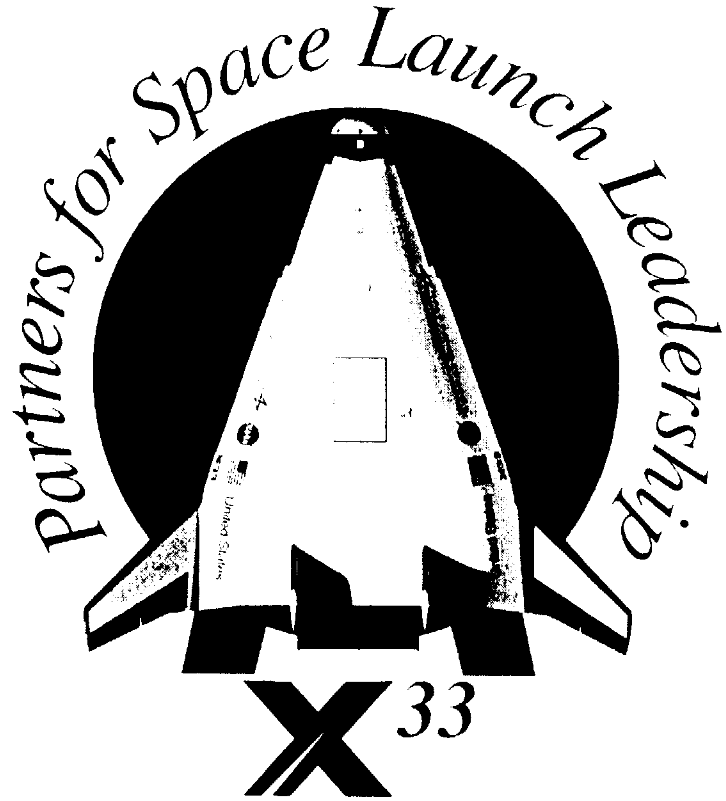
X-33 and RLV for the Future



Military Space Conference
London, UK

September 14, 2000

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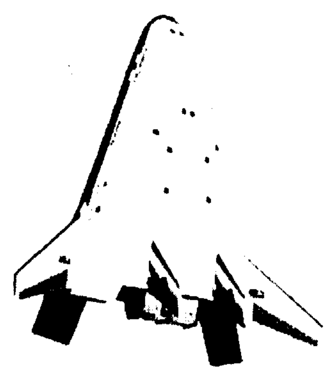
Deputy Program Manager
X-33 Program
NASA/Marshall Space Flight Center
Located at:
Lockheed Martin Aeronautical Co.
Palmdale, CA, USA

X-33 Overview

- In 1996, NASA selected an industry team lead by Lockheed-Martin to build and fly a technology demonstrator single stage to orbit (SSTO) vehicle- <u>designated the X-33.</u>
- Since then, a joint NASA/Industry team has been designing, testing, and building the X-33 vehicle.
- Primary Objectives of the X-33 Program :
  - Demonstrate the Technologies Required for a Next - Generation SSTO System,
  - Demonstrate Reduced Launch Cost, Rapid Launch Turnaround Times, Increased Reliability, and
  - Reduce Technical and Programmatic Risks Sufficient to Encourage Private Financing of the Development and Operation of a Next-generation System.

X-33 Overview



¥ Flight engines delivery: Dec. 00

¥ Protoflight tank test: Apr. - May 01

¥ Vehicle rollout: Feb. 02

¥ First flight: Fall 02

¥ Seven flights planned to Mach 13

¥ X-33 provides airplane-like access to space. Stages do not separate and need not be recovered.

¥ X-33 takes off vertically and glides to a horizontal landing like the Space Shuttle.

¥ Uses liquid oxygen and liquid hydrogen propellants

¥ Demonstrate aircraft-like reusability, maintenance and scheduling

¥ Robust metallic TPS system

¥ Linear Aerospike engine

¥ Vehicle health monitoring system

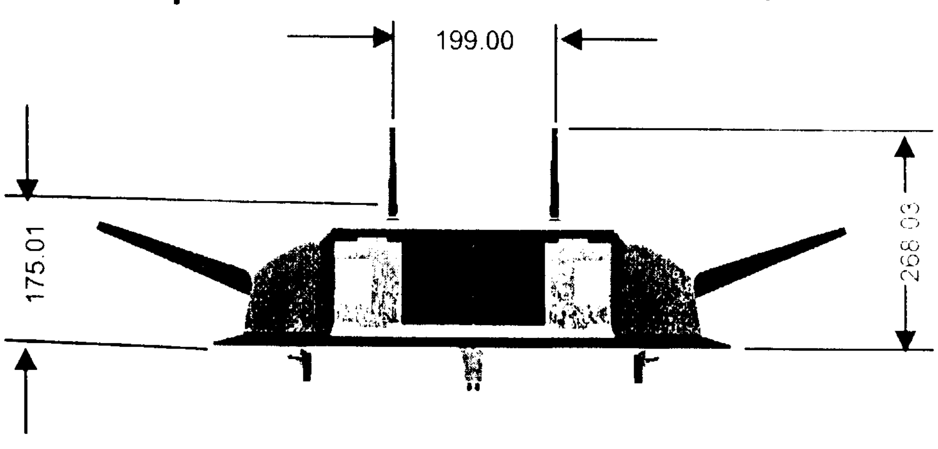
¥ Aerothermal environment prediction verification

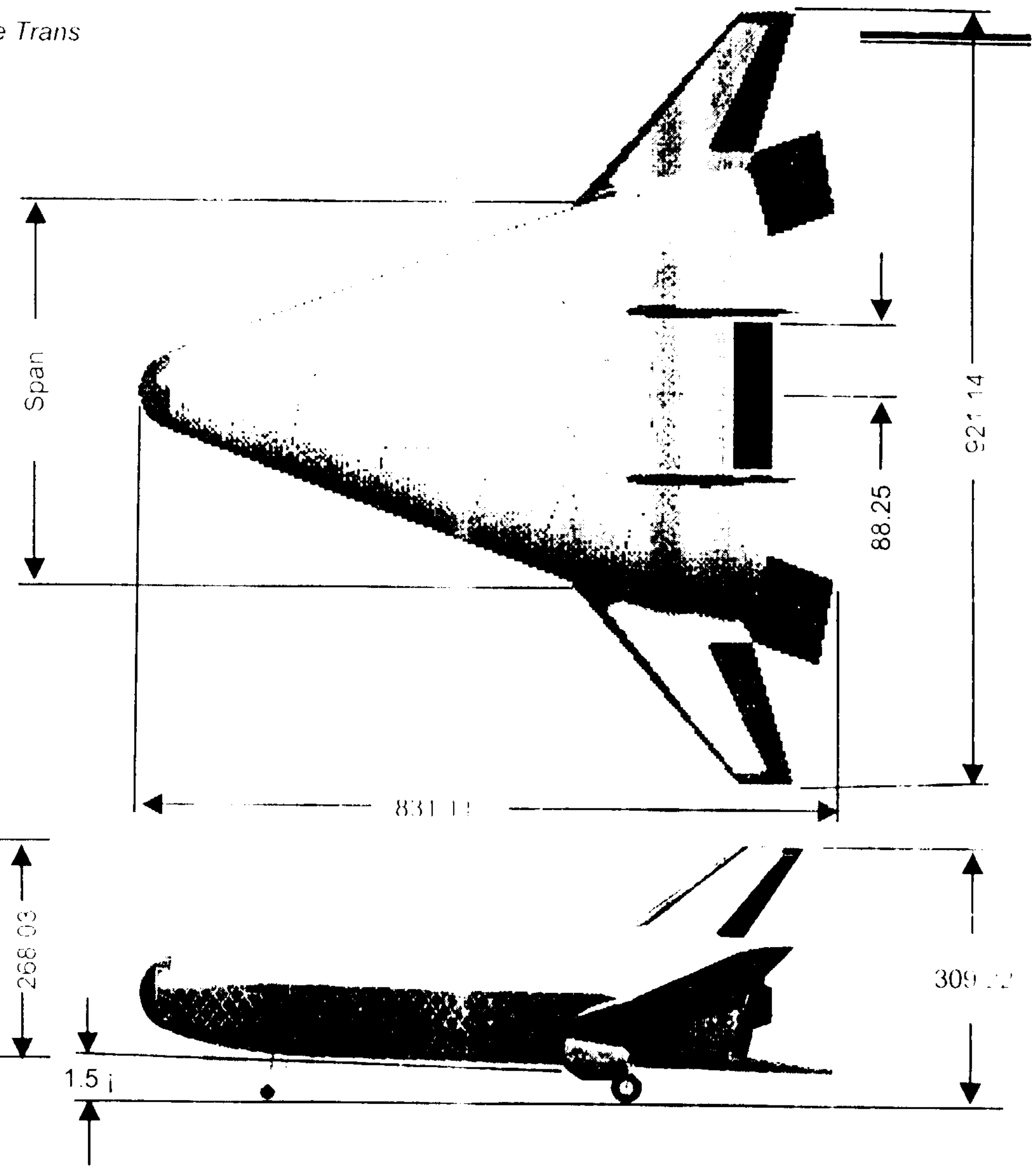
¥ Lifting body design

X-33 3-View

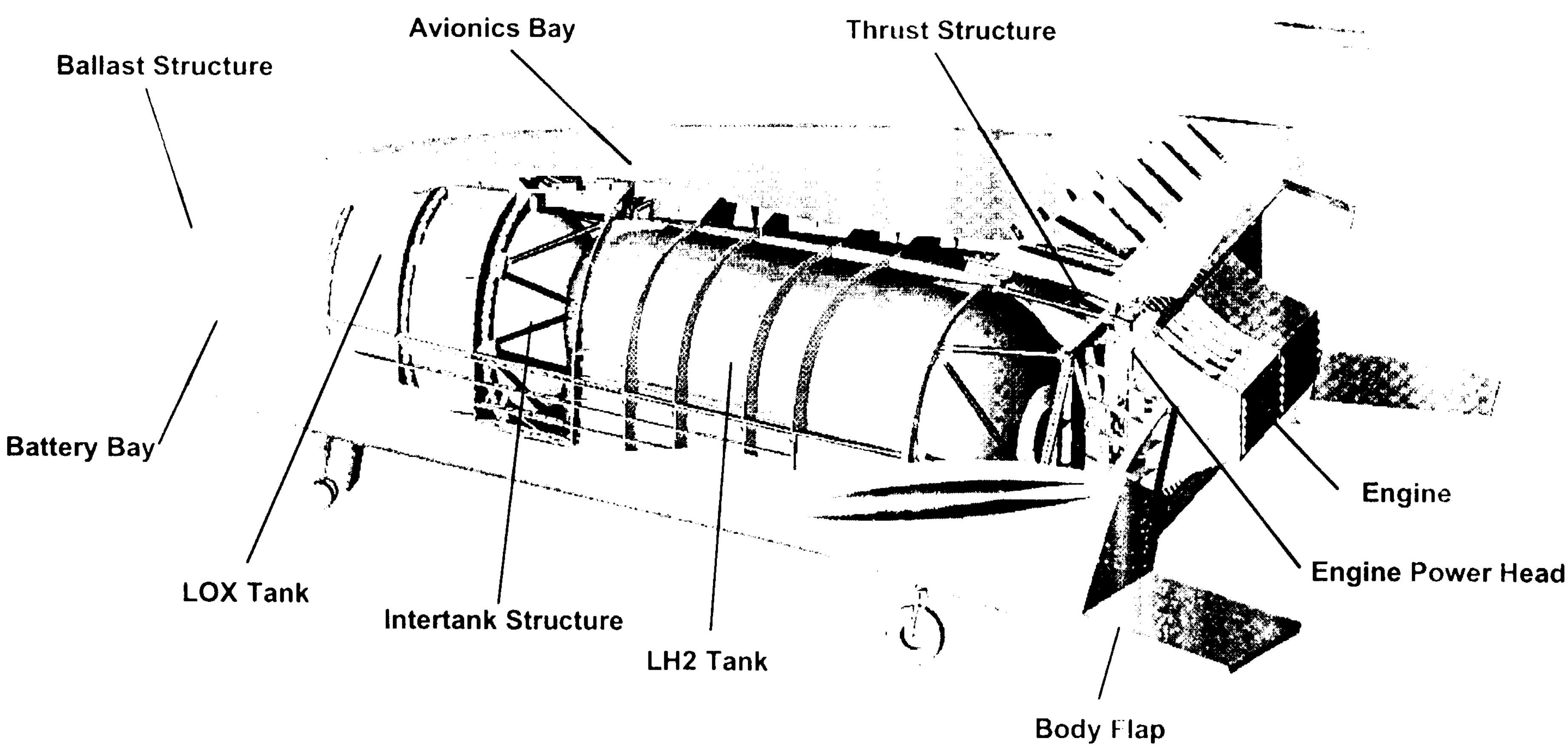
Space Transportation Directorate . . . . Revolutionizing Space Trans

Area (Reference)........................1608 ft^2
Span.......................................36.3 ft
Length (Along centerline)..........63.2ft
Canted Fin Area (Total)..............376ft^2
Vertical Fin Area (Total).............170ft^2
Body Flap Area (Total)................164ft^2
LH_2 Tank Volume (Total)..........7673 ft^3
LOX Tank Volume.....................2587 ft^3
GLOW ..285,000 lbs
LH2 .30,000 lbs
LO2 ..180,000 lbs
Take-off thrust .410,000 lbs
Max. Speed .Mach 13.8

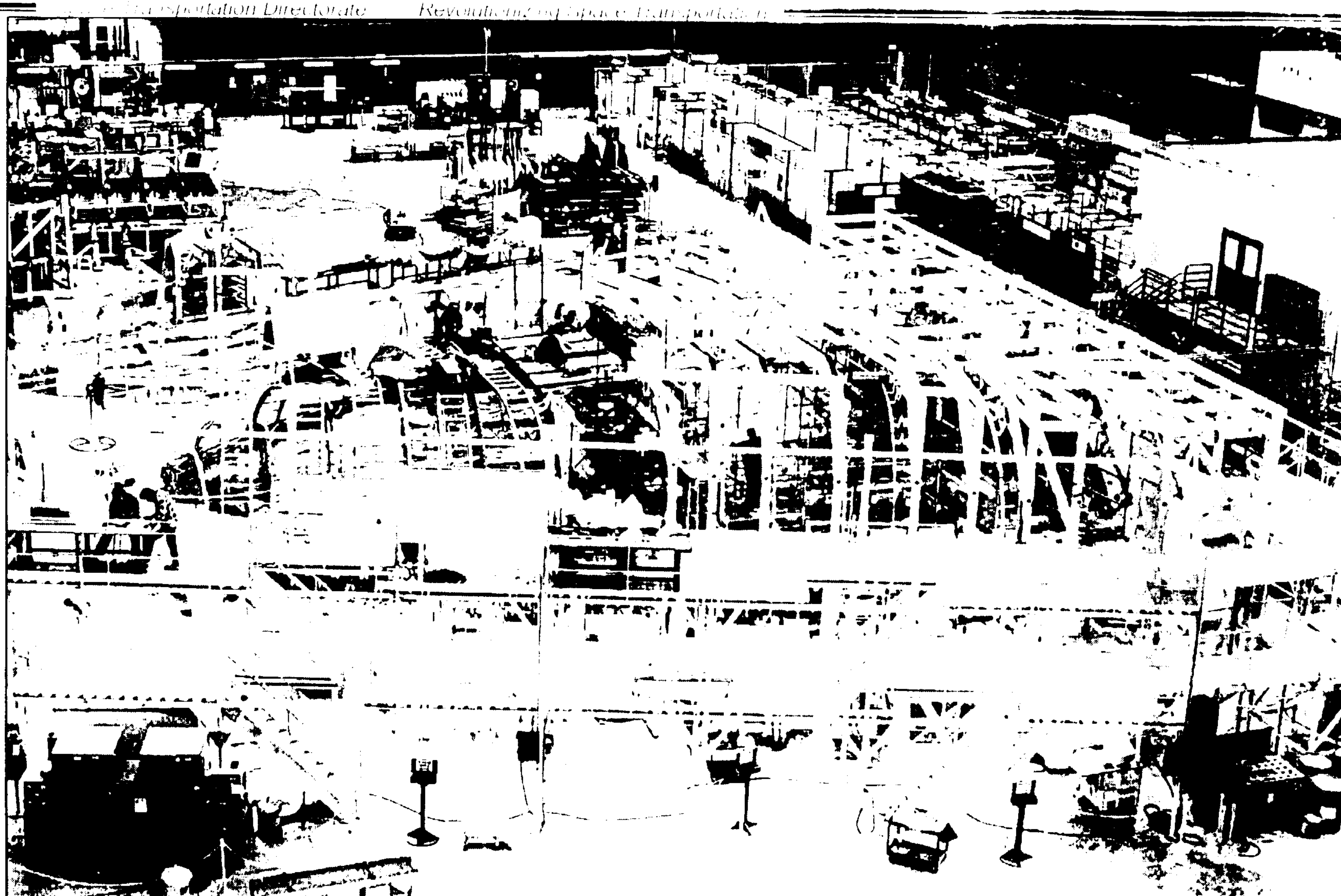




X-33 Internal Arrangement

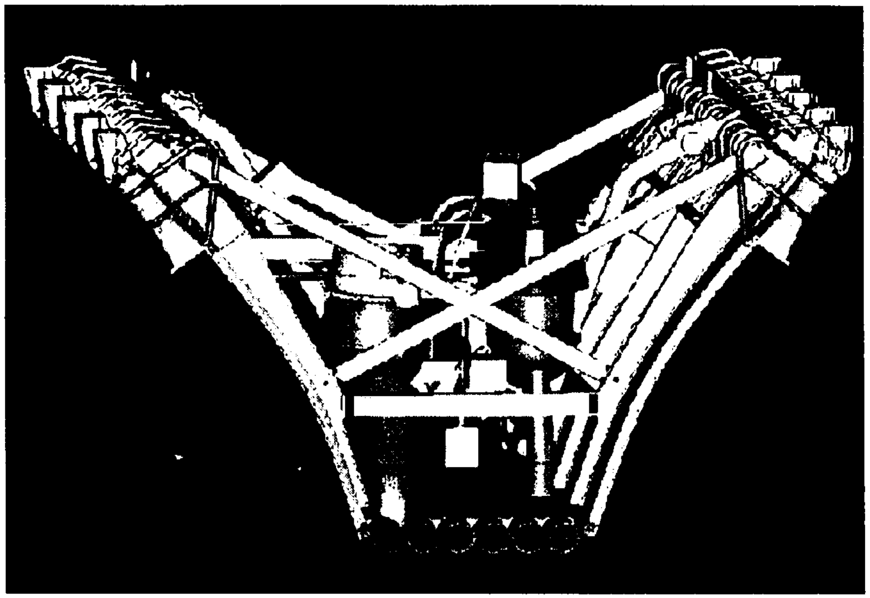


X-33 Assembly Floor



Crews Wiring X-33 s Avionics Bay Within Primary Assembly Structure

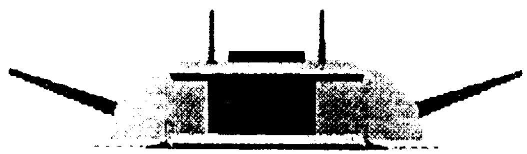
X-33 Linear Aerospike



F, sea level/vacuum, Klbf.	206.5/268
Isp, sea level/vacuum, sec.	339/439
Chamber pressure, psia.	857
Area ratio	58
Thrust cells	20
Propellants	Ox/hydrogen
Mixture ratio, o/h	5.5
Cycle	Gas generator
Throttling, % thrust	50 - 105
Thrust/weight	35
Dimensions,	inches
Forward end	133w x 88l
Aft end	46w x 88l
Forward to aft	79

- ¥Enables smallest, bwest cost vehicle
  - ¥Smallest thrust take-out structure
  - ¥No gimbaljoints or actuators
- ¥Lowest development risk
  - ¥Lowest risk cycle, gas generator
  - ¥Parallel compcnent development

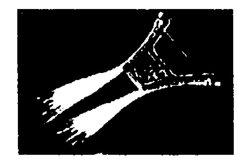
X-33 Two Engine Thrust Vector Control



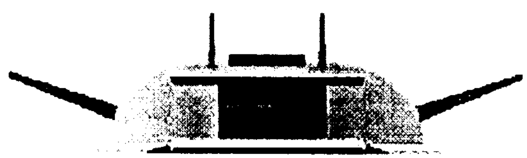
Positive Pitch Control

Legend

	Higher thrust
	Lower thrust

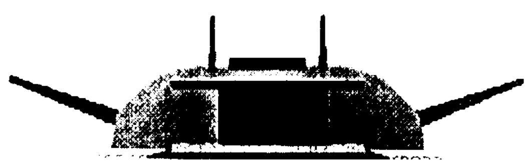


Level Flight

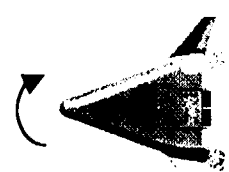


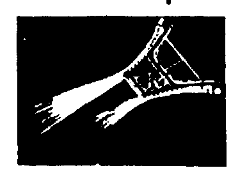
Positive Roll Control

Pitch Up



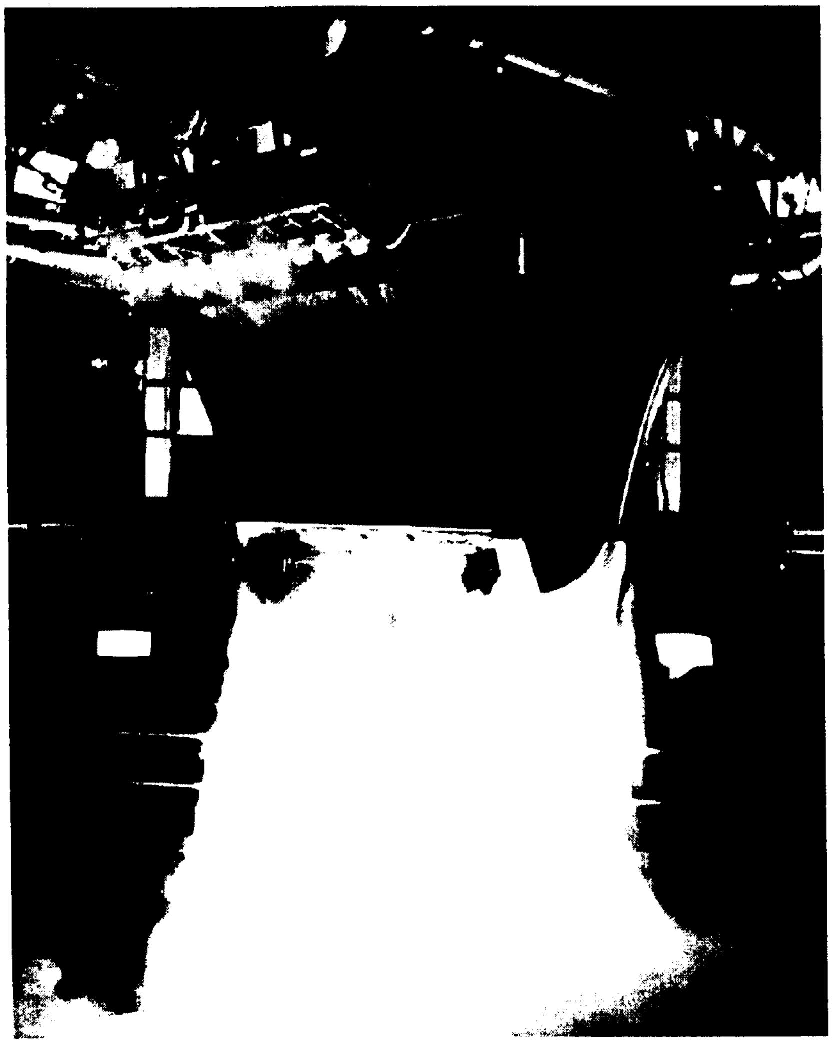
Positive Yaw Control





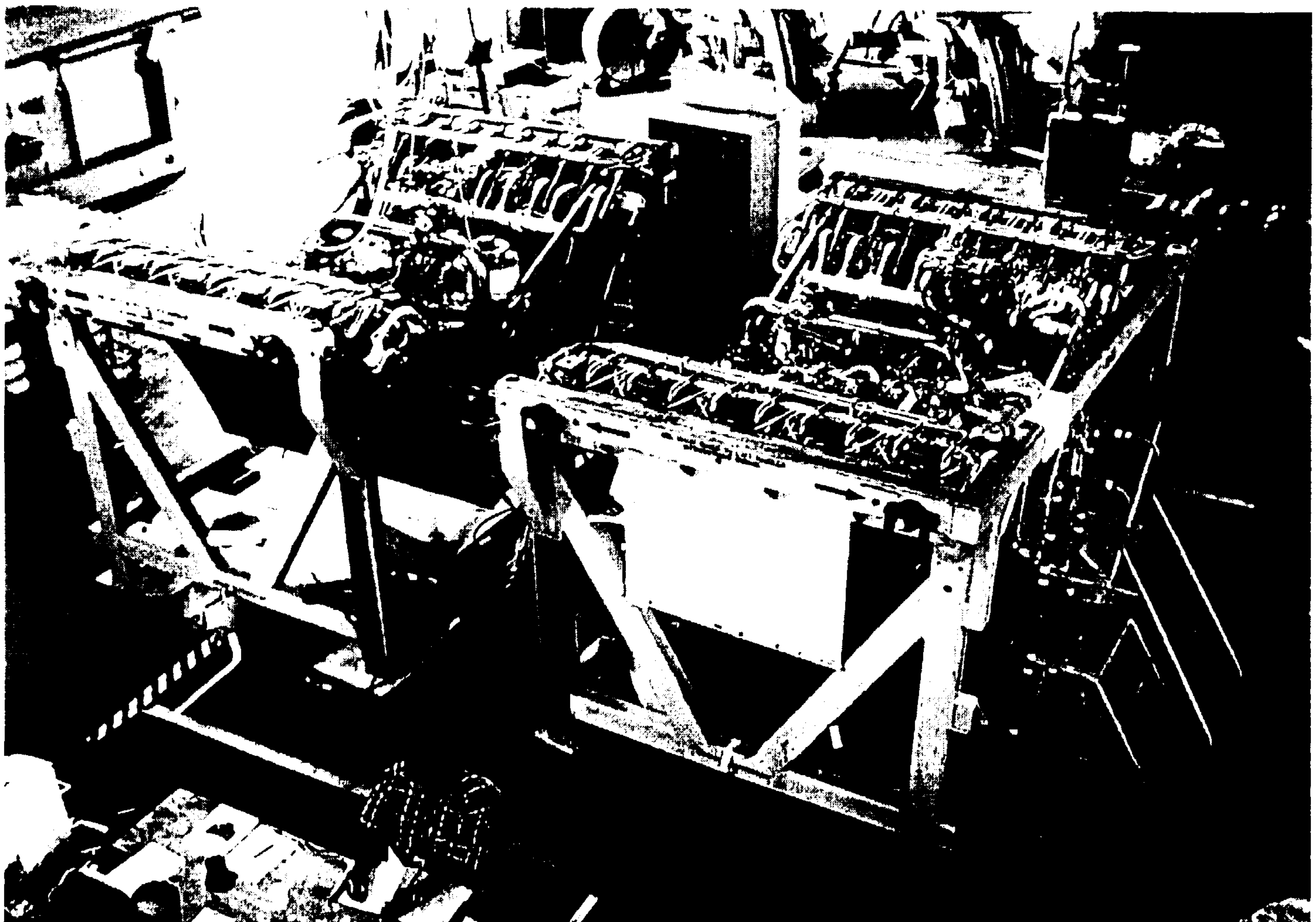
Pitch Down

X-33 Aerospike Testing

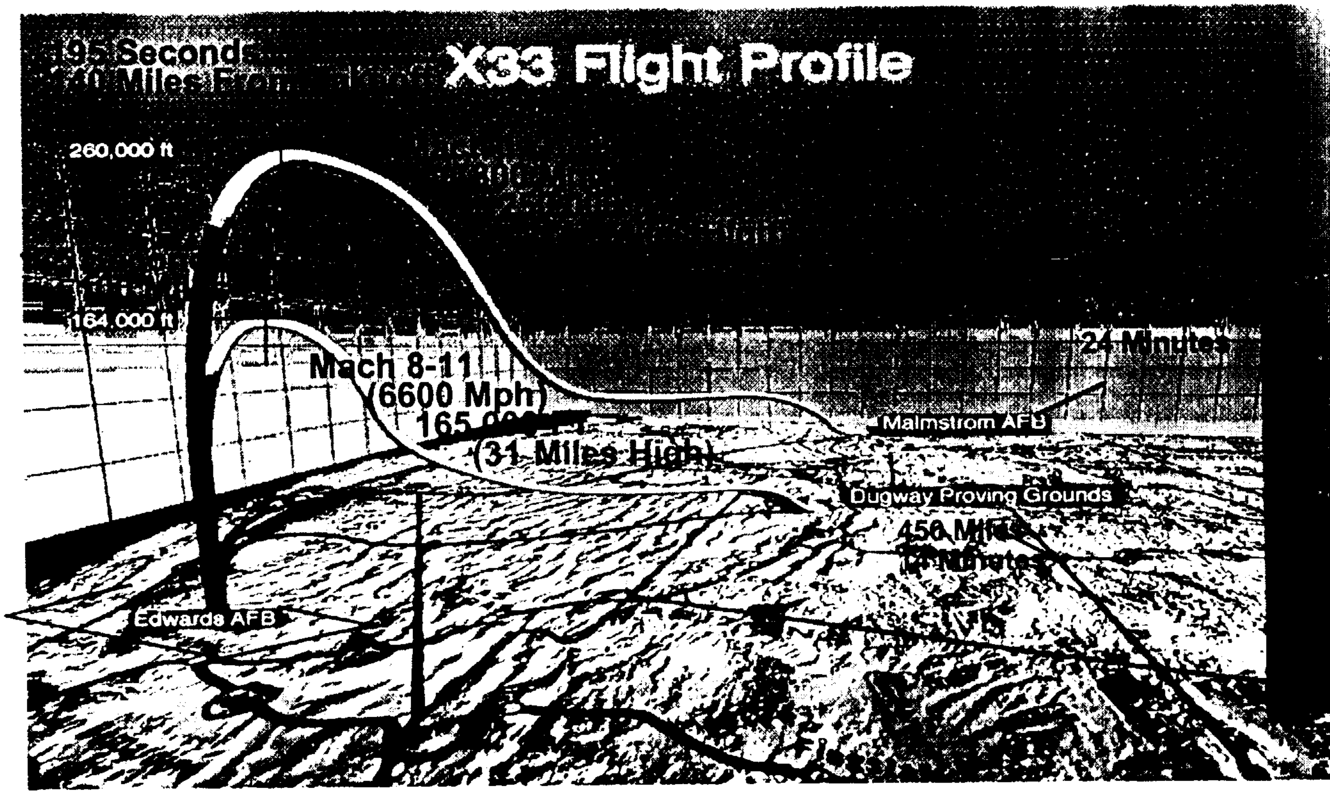


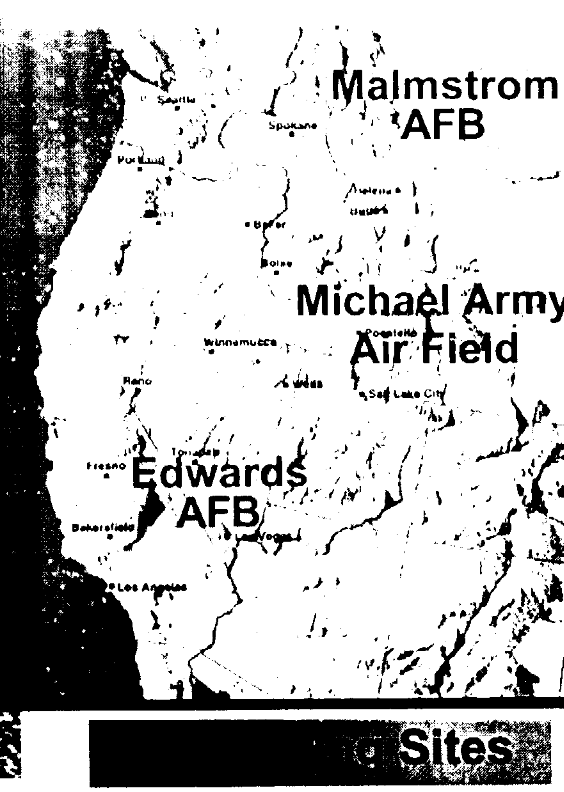
- **Unprecedented success achieved with extensive test program**
  - Single thruster - 13 tests, 985 seconds
  - Multi-Cell - 10 tests, 49 seconds
  - Powerpack - 17 tests, 1506 seconds
  - Single Engine - 14 tests, 1513 seconds
  - Full power achieved in 6 tests

Engines 2 & 3 Ready To Mate



X-33 Flight Test

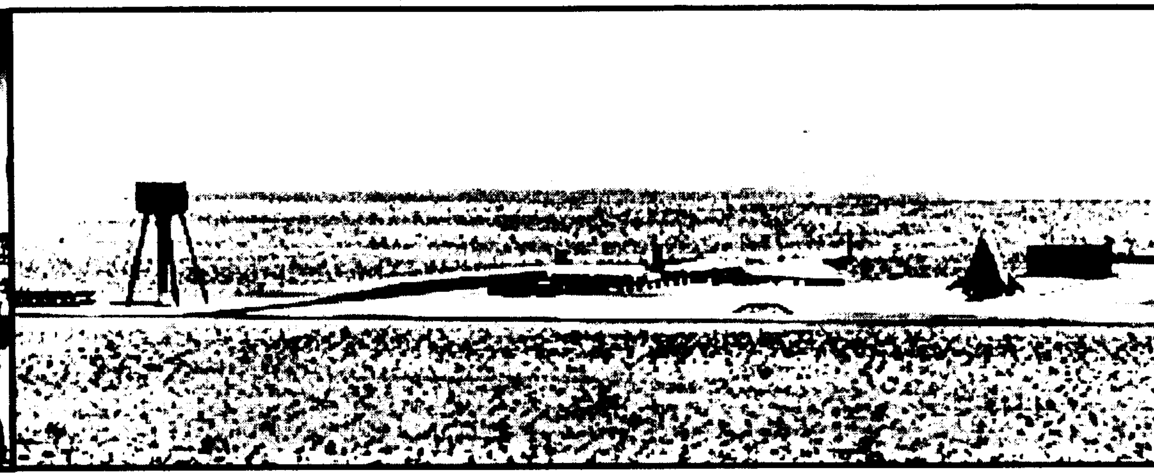




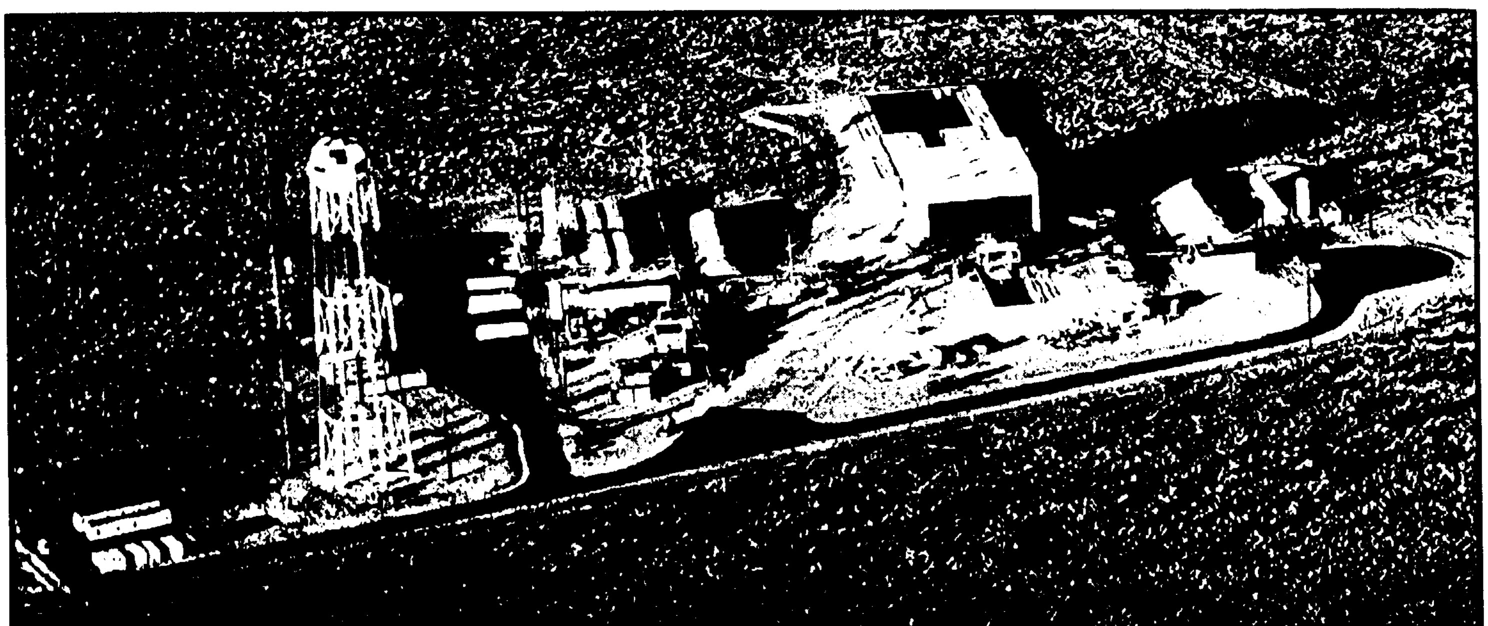
Aircraft-like Operations: Two Seven-Day Turnarounds and One Two-Day Turnaround During Flight Test Series

X-33 Flight Operations Center

Ground Breaking Nov '97



Artists Concept



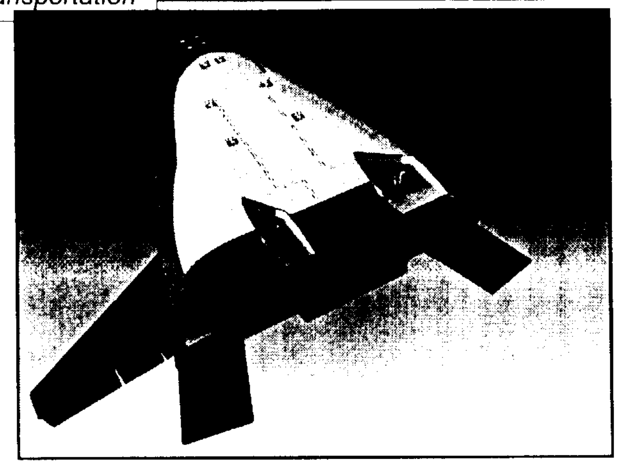
Status: Site Activation Complete

X-33 to RLV Evolution

¥ <u>Objectives</u>

— Build & test a 53-perent scale demonstrator for an SSTO RLV

— Validate design tools & processes

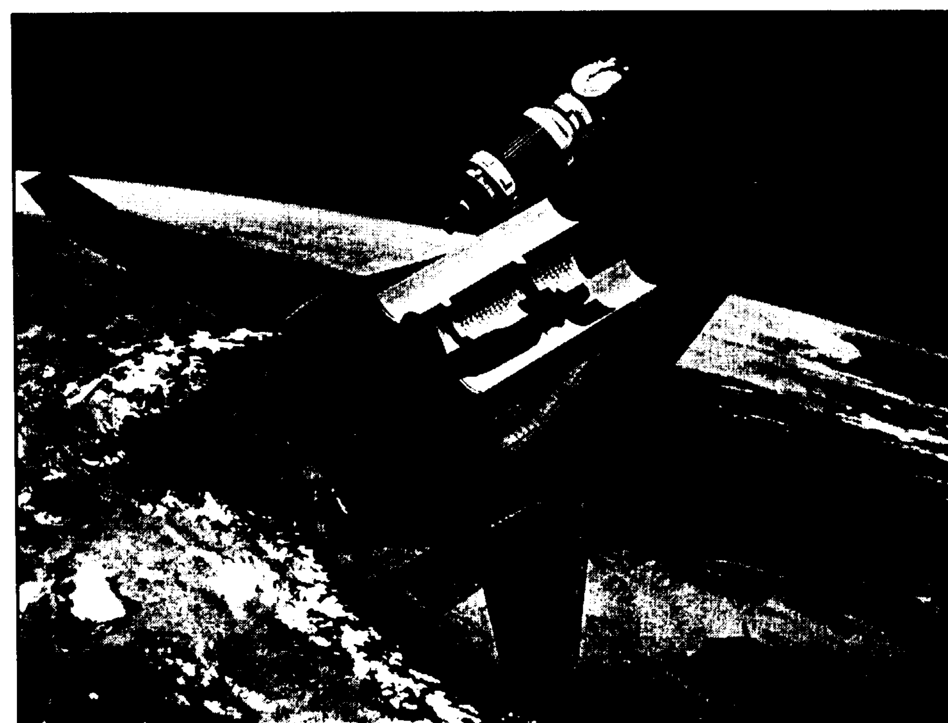


¥<u>Long-term goal:</u>

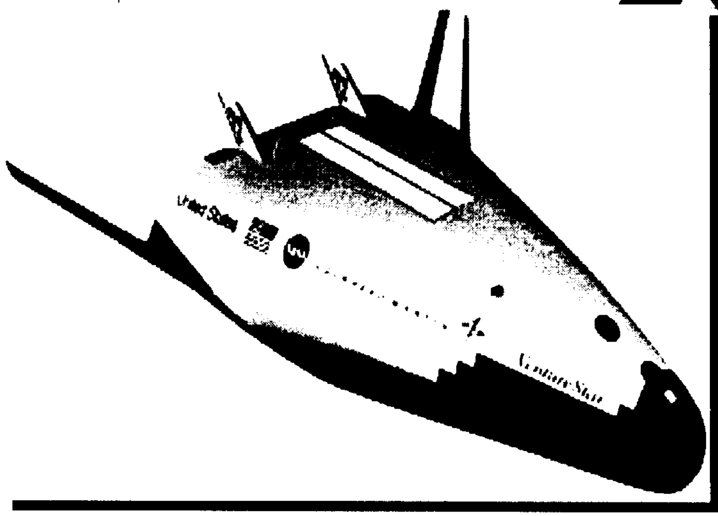
— Increase launch vehicle reliability and reduce payload cost to low Earth orbit by factor of 10 ($10,000 to $1,000 per lb.)

¥50,000+lb. Payload to 100NM / 28.5¡ Orbit

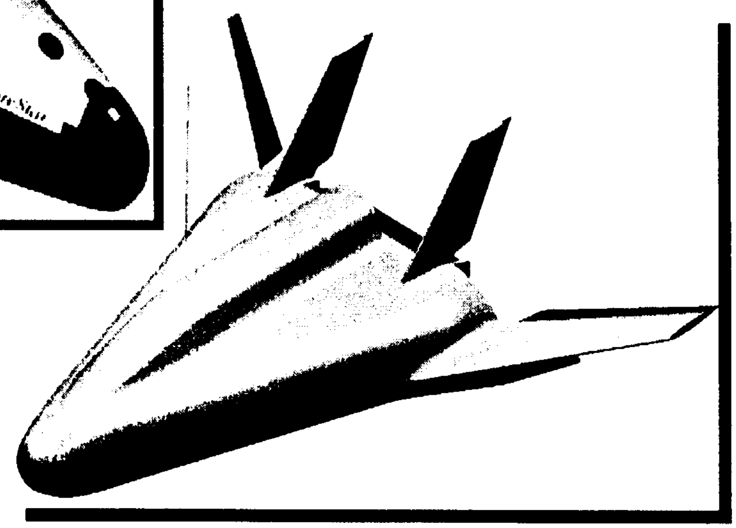
¥Meet Government and Commercial Launch Requirements



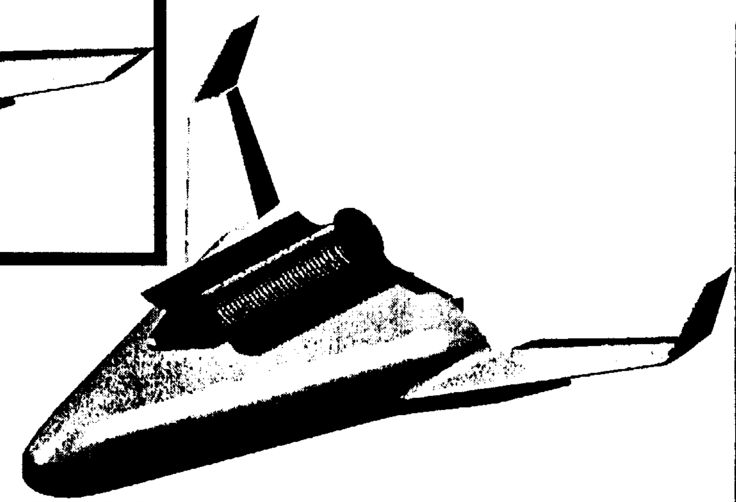
VentureStar Design Evolution



X-33 Heritage: Internal Payload Concept

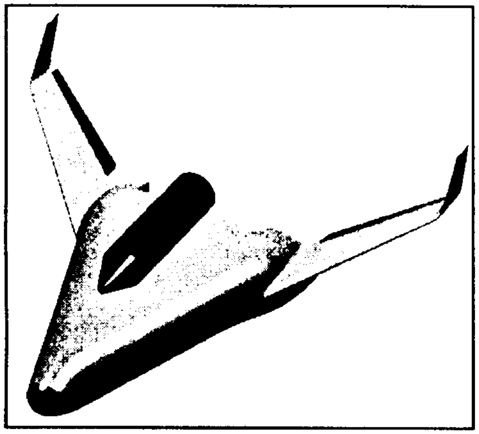
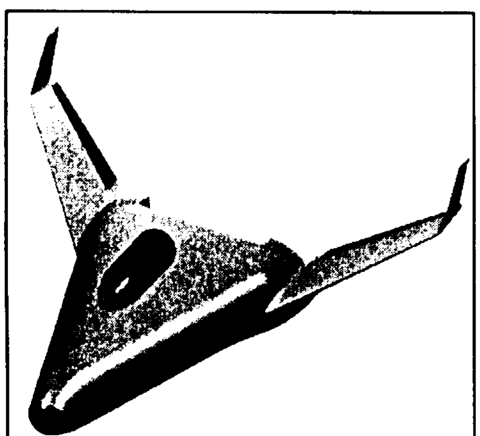
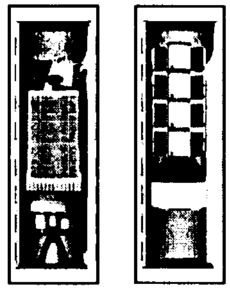
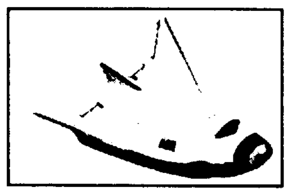
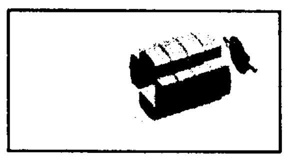
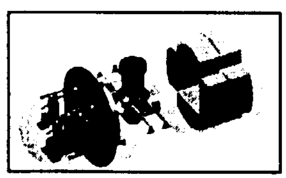
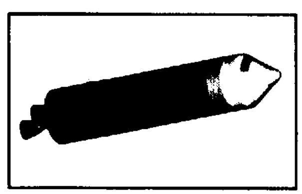


Semi-Submerged Payload Concept



External Payload Concept

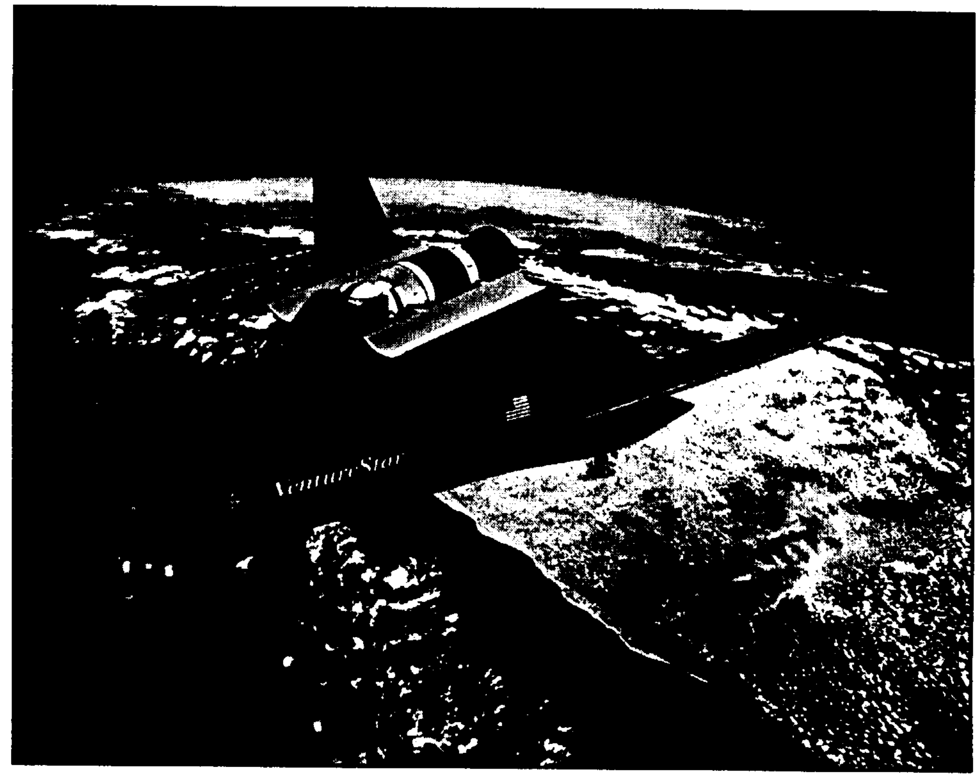
Operational Flexibility

- Standard Mission Module
  - Reconfigurable for cargo delivery/deploy mission
- Crew Module/Crew Transfer Vehicle
  - Designed to carry crew to/from space
  - Nominally flown on-back
  - Provisions for contingency release
  - Possible Independent operation
    Winged CTV
- ISS Mission Module(s)
  - Designed to fly in place of standard mission module
  - Optimized for minimum logistics flights
  - Crew/cargo or cargo only mix
- Crew/On-orbit Mission Module(s)
  - Orbit Crew Transfer Vehicle
  - Platform for on-orbit operations
  - Contingency deploy/recovery for crew
  - Potential for free-flight operations

Minimizing Risk

- Looking at Opportunities for Additional Risk Mitigation Technologies
- Additional RLV Technologies:
  - Metallic LH2 Tanks (Same FFF)
  - Composite Engine Ramp (Current Metallic)
  - Carbon Carbon Elevons (Metallic & Ceramics)
  - Refine JPL GPS/INS
  - Densified (Colder) Propellants
  - Other Technologies for Low Operations & Life-Cycle Costs



Future RLV Spaceport

- Facilities & systems to enable system operations
  - Flight segment
    - ♦ Maintenance
    - ♦ Final assembly
    - ♦ Launch / landing
    - ♦ Payload processing
  - Ground systems
    - ♦ Propellant supply
    - ♦ Utilities
  - Support infrastructure
    - ♦ Office buildings
    - ♦ Logistics areas
    - ♦ Security